## XVII. *Some further Observations on Atmospherical Refraction.* *By* Stephen Groombridge, *Esq. F. R. S.*

Read March 31, 1814.

In my former paper on atmospherical refraction, communicated to the Royal Society by my late friend, Dr. Maskelyne, I considered the few observations made below 80° of zenith distance, as not sufficiently to be depended on, for the computation of a general formula of refraction: and I therefore used $\eta$ Ursæ Majoris (78° 10′ zen. dis.) as the lowest star for that purpose. Having since applied the computed refraction from the formula thence obtained, to observations of stars below 80°, I have noticed, that such stars so corrected, appeared to be further from the zenith below the Pole, than they ought to have been, from the observations above the Pole: and therefore that the refraction was less at those distances from the zenith, than I had assumed. This has induced me, in the years 1811 and 1812, to make a course of observations of stars below the Pole, above 80° zenith distance; and as near to the horizon, as the trees in Greenwich Park would permit; these being higher than the level of my Observatory. It may also be remarked, that those stars in my former table below 80°, produce the co-latitude in excess; as a confirmation, that the same formula will not apply to those larger arcs, where, from the rapid increase of the tangents, a small error in the assumed quantity becomes more sensible. Although various hypotheses may be formed, from the known density and tem-

perature of the atmosphere; and from these causes may be computed the effect they should have on a ray of light passing through the same: yet we must resort to observation, for the verification of the theory; and reduce the quantity so found, to the most simple and convenient formula. I shall proceed to deduce, from this course of observations, such formulæ as will appear to result, for the computation of the refraction; from the zenith, to the lowest star which I have observed: these may be considered as sufficient for the observation of the sun at the winter solstice, in high latitudes; since those of the moon, from its great parallax, and the planets from their general invisibility, would probably not be attempted. Nevertheless, it is to be wished, as a matter of curiosity, or from which some useful deductions might be made, that in those Observatories, wherein from their elevated situations it might be practicable, the true quantity of refraction should be ascertained to the horizon.

Of all the formulæ for computing the mean refraction, that proposed and used by Dr. BRADLEY, is the most convenient and applicable for the practical astronomer. But as it is now acknowledged, that the numbers he had assumed for the coefficient of $r$ (the refraction;) and of $x$ (the quantity at 45°) were too small: their real values will appear to be the mean of several arcs, and such as I now propose to be adopted. I have found, that the same formula will serve to 87° of zenith distance; possibly this might not happen in low situations, where the height of the vapours would form a greater angle with the horizon: yet in more elevated places, we may reasonably suppose, that a general formula might be carried nearly to the horizon.

In the two annexed tables are given the mean of the observed zenith distances of the several stars; and in the next column the mean refraction, computed from the formula which I proposed in my former paper; viz. tang. $\overline{z - 3.3625\, r} \times 58'', 1192$: and which has been applied to these observations, corrected for the barometer and thermometer. In the following column, the error or difference is shewn, between the computed and real zenith distances; the assumed mean refraction, corrected by these errors, will give the mean refraction, which should have been applied. From these last quantities are deduced the respective values of ($y$) the coefficient of $r$, and of $x$: and from the mean of the sixteen stars, the resulting numbers will be $y = 3.6342956$, $x = 58.''132967$. Having therefore reduced the whole sixteen by these mean values of $y$ and $x$; the error or difference is noted, when compared with the corrected mean refraction which should arise from observation. On a review of these errors, and noticing the mean state of the thermometer for each star, the errors seem to indicate a small correction. I assumed in my former paper, that the refraction as affected by the thermometer, varied in an arithmetical ratio of ,0021 for each degree of FAHRENHEIT's scale; and the mean state to be at 45° for the thermometer without. Continuing the same mean state, and changing the ratio to ,0020, these errors will be affected $\frac{1}{10000}$ of the refraction, for each degree above and below 45°; which being applied, will reduce the final error, as shewn in the last column.

In the same manner I proceeded to find the values of $y$ and $x$, from the six lower stars, contained in the second table; but the respective values of both $y$ and $x$ were variable, and each

in a decreasing ratio. To discover the law of variation for each, would have been complex; therefore retaining the value of $x$ as general, I found $y$ to vary as the minutes of each degree above 87° × ,00462; the co-efficient ($y$) of $r$ when so reduced is given; the mean refraction resulting, is contained in the following column; and being corrected for the new factors of the thermometer, there remains the final error.

With a view to assist me in ascertaining whether the refractions were affected by local vapours, Dr. BRINKLEY has kindly communicated to me some observations of low stars; which when reduced by the same formula do not materially differ from my own. 12 Can. Ven. at 87° 2′ and $\alpha$ Lyræ at 87° 42′ of which there are the greater number of observations, the former gives the same result within half a second, and the latter $1\frac{1}{2}''$.

Several of the fixed Observatories in Europe being situated in sufficiently high latitudes to obtain the elevation of the pole with much correctness; we are thence enabled, by the circumpolar stars, to find the true quantity of refraction, for all zenith distances: and this having been so ascertained, we may apply the same to the observed zenith distance of the sun, at the winter solstice, as a test of its accuracy. With the smaller quantities of refraction, which were used by Dr. BRADLEY and others, fifty years since, it was not possible, that the latitude deduced from the elevation of the pole, and the mean of the solstices, could agree; the distance of the pole from the equator, so computed, would be less than 90°. Hence also, the two solstices would shew an error of double that difference in the obliquity of the ecliptic, when obtained from the greatest and least zenith distances of the sun. The small number of

observations I have been able to make of the sun, to ascertain the agreement of the two solstices, are subjoined; these appear to confirm the refraction, as deduced from the circumpolar stars.

In the course of my observations I have noticed, that applying the correction for the thermometer without, gives the most accurate result. The difference is very sensible in great zenith distances, from the greater quantity of refraction; and we may reasonably infer, that when the front shutter of the Observatory is opened, the horizontal current of the air is of the same temperature as without; although from the short time of the shutter being opened, during the observation, it is not indicated by the thermometer in the telescope. I have therefore constantly used the thermometer without, for the correction, when I have opened the front shutter; but on all other occasions, I have applied the correction for the thermometer within. The instrument is protected from the horizontal current of air, when the sloping shutters in the roof only are opened; the front shutters being five feet above the graduated circle.

Having formerly proposed certain factors for the thermometrical correction of the refraction, and now finding them relatively the same for the thermometer within and without, changing the ratio for each degree of FAHRENHEIT $\frac{1}{10000}$; I shall adopt, hereafter, the following formula. Putting $h^\circ$ for the degree of the scale; then for the thermometer within, $\overline{49^\circ - h^\circ} \times ,0023$ when below the mean; $\overline{49^\circ - h^\circ} \times ,0022$ when above the mean: and for the thermometer without, $\overline{45^\circ - h^\circ} \times 0020$; will produce the respective factors. When $h^\circ$ is less than the mean, these will be positive; when greater

than the mean, negative. These factors of different values will be nearly the same for the thermometer within and without, in summer; when the temperatures approximate: but in winter, when the temperatures may differ 6° or 8°, the factors will vary accordingly. It may therefore not be material, when the quantity of refraction is small, not exceeding $1\frac{1}{2}'$, whether the correction is applied for the thermometer within or without; but when the temperature within is supposed to be affected by the horizontal current from without, I should recommend, in all such cases, the use of the latter correction.

To make a direct comparison of these refractions with the French tables, it may be objected, that the latter being computed for the metrical barometer 0,760 m., which is equal to 29,93 inches of our barometer, the mean refraction from the proposed formula should be increased by the factor +,0111; since we reckon the mean state at 29,60 inches: but, the metrical thermometer at + 10 being equal to ours at 50°; and the mean state being determined from observation, to be 45° of FAHRENHEIT; the factor for 50° will be — ,0100; which will nearly compensate the factor for the barometer. I have therefore compared the mean refractions resulting from my formulæ, with those of the French tables, from 80° to 90°: excepting the two last, the difference is not considerable; and whether these arise from defect in the formulæ, or from local causes, can only be determined by observation.

On comparing the refractions, now proposed, with my former deductions, they will not differ one second at 81°. At 72° the present is $\frac{1}{10}$ of a second less than the former; and at 74° 50′ the zenith distance of the winter solstice, 0,″18 must be deducted as a correction. It will appear on inspection of

the second table, that $\beta$ Persei at 88° 1′ requires but a small equation (— 2″,41) when computed from my former numbers; and at 88° both these formulæ will coincide. I had therefore, in my former paper, determined too hastily, that the formula proposed would agree with observation so far as 88°; not having then discovered the discrepancies between 80° and 88°, which are corrected by the present formula.

In order to facilitate the computation of the true refraction, it is required to form a table of mean refractions from certain formulæ. This may appear difficult at the first view; since every refraction must become equal to, tang. $\overline{z - yr} \times x$; and unless $r$ is assumed very nearly, several operations may be necessary before the differences will vanish. However, proceeding in small arcs of 10′ to 70°, of 5′ to 86°, of 4′ to 88°, of 3′ to 89°, and of 2′ thence to the horizon, the second differences of the variation of these arcs may always be taken by inspection: and the resulting refraction will be equal to that assumed, in one operation. The correction for the barometer and thermometer will be the sum of the two factors in the annexed tables, into the mean refraction: and the product added thereto, according to the algebraic sign of their sum, will give the true refraction. This method is more expeditious, than by logarithms; no other tables of reference being required: and the computation will be effected with a small number of figures; which is an object I have constantly had in view.

S. GROOMBRIDGE.

Blackheath, 31 January, 1814.

## *Reduction of the Solstices.*

| 1810. | | | Zen. dis. corrected. |
|---|---|---|---|
| | | | ° ′ ″ |
| Dec. 14 | - | | 74 . 55 . 53.96 |
| 26 | - | | - 52.53 |
| 27 | - | | - 49.75 |
| 30 | - | | - 52.66 |
| | | | 74 . 55 . 52.23 |
| Nutation | + 9.60″ | | |
| Parallax | − 8.59 | + | 1.11 |
| Sun's lat. | + 0.28 | | |
| Corr. refr. | − 0.18 | | |
| | | | 74 . 55 . 53.34 |
| Latitude | | | 51 . 28 . 2.18 |
| Mean obliq. eclip. | | | 23 . 27 . 51.16 |

| 1812. | | | Zen. dis. corrected. |
|---|---|---|---|
| | | | ° ′ ″ |
| June 7 | - | | 28 . 0 . 25.76 |
| 14 | - | | - 23.05 |
| 15 | - | | - 23.74 |
| 29 | - | | - 23.04 |
| July 5 | - | | - 23.42 |
| | | | 28 . 0 . 23.80 |
| Nutation | − 8.56″ | | |
| Parallax | − 4.04 | − | 13.61 |
| Sun's lat. | − 1.01 | | |
| | | | 28 . 0 . 10.19 |
| Latitude | | | 51 . 28 . 2.18 |
| Mean obliq. eclip. | | | 23 . 27 . 51.99 |

| 1811. | | | |
|---|---|---|---|
| Dec. 9 | - | | 74 . 55 . 53.64 |
| 16 | - | | - 52.11 |
| 22 | - | | - 49.79 |
| 23 | - | | - 55.20 |
| 25 | - | | - 50.96 |
| 1812 30 | - | | - 52.30 |
| Jan. 2 | - | | - 55.41 |
| | | | 74 . 55 . 52.77 |
| Nutation | + 9.16 | | |
| Parallax | − 8.59 | + | 0.22 |
| Sun's lat. | − 0.17 | | |
| Corr. refr. | − 0.18 | | |
| | | | 74 . 55 . 52.99 |
| Latitude | | | 51 . 28 . 2.18 |
| Mean obliq. eclip. | | | 23 . 27 . 50.81 |

| 1812. | | | |
|---|---|---|---|
| Dec. 7 | - | | 74 . 55 . 57.51 |
| 8 | - | | - 50.51 |
| 11 | - | | - 55.93 |
| 13 | - | | - 54.60 |
| | | | 74 . 55 . 54.64 |
| Nutation | + 7.68 | | |
| Parallax | − 8.59 | − | 1.61 |
| Sun's lat. | − 0.52 | | |
| Corr. refr. | − 0.18 | | |
| | | | 74 . 55 . 53.03 |
| Latitude | | | 51 . 28 . 2.18 |
| Mean obliq. eclip. | | | 23 . 27 . 50.85 |

## TABLE I.

| Star. | No. Obs. | Observed Zenith Distance. | Mean Refraction. | Error from Observ. | Mean Refrac, correc | Mean Therm. | $y$ the coeff. of $r$. | $x$ the Refrac at 45°. | Tang $\overline{x-yr}$ X $x$. | Error. | Therm. correct. | Final Error. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ° ′ ″ | ′ ″ | ″ | ′ ″ | | | ″ | ′ ″ | ″ | ″ | ″ |
| τ Herculis | 15 | 81 39 30.08 | 6 19.96 | + 1.06 | 6 18.90 | 40 | 3.62402 | 58.13601 | 6 18.84 | — 0.06 | — 0.22 | — 0 28 |
| Capella | 30 | 82 37 49.50 | 7 6.07 | + 1.12 | 7 4.95 | 62 | 3.55849 | 58.13114 | 7 4 49 | — 0.46 | + 0.72 | + 0.26 |
| ψ Ursæ maj. | 14 | 82 53 1.76 | 7 19.80 | + 1.65 | 7 18 15 | 40 | 3.62441 | 58.13499 | 7 18.11 | — 0.04 | — 0.22 | — 0 26 |
| β Aurigæ | 33 | 83 29 36.28 | 7 56.66 | + 2 01 | 7 54.65 | 61 | 3.61064 | 58.13373 | 7 54.45 | — 0.20 | + 0.76 | + 0.56 |
| α Cygni | 29 | 83 47 18.26 | 8 16 55 | + 2.61 | 8 13.94 | 40 | 3.65160 | 58.13613 | 8 14.09 | + 0.15 | — 0.25 | — 0.10 |
| ω Ursæ maj. | 10 | 84 12 4 14 | 8 47.17 | + 4.08 | 8 43.09 | 32 | 3.74129 | 58.14097 | 8 44.21 | + 1.12 | — 0.68 | + 0 44 |
| κ Persei | 11 | 84 15 26.81 | 8 51.62 | + 3.04 | 8 48 58 | 53 | 3.63505 | 58.13429 | 8 48.58 | 0.00 | + 0.42 | + 0.42 |
| λ Ursæ maj. | 10 | 84 31 48.93 | 9 14.14 | + 4 30 | 9 9.84 | 36 | 3.70809 | 58.13838 | 9 10.72 | + 0.88 | — 0.50 | + 0.38 |
| ι Aurigæ | 13 | 84 50 58.25 | 9 42.81 | + 2.64 | 9 40.17 | 59 | 3.54668 | 58.12771 | 9 38 85 | — 1.32 | + 0.81 | — 0.51 |
| 11 Lacertæ | 15 | 85 4 10.55 | 10 4 18 | + 4.37 | 9 59.81 | 37 | 3.63439 | 58.13276 | 9 59.79 | — 0.02 | — 0 48 | — 0.50 |
| κ Andromedæ | 11 | 85 4 32.79 | 10 4.79 | + 4 48 | 10 0 31 | 42 | 3.64000 | 58.13328 | 10 0.40 | + 0.09 | — 0.18 | — 0.09 |
| ξ Cygni | 14 | 85 10 51.26 | 10 15.52 | + 4 83 | 10 10.69 | 39 | 3 64778 | 58.13364 | 10 10.91 | + 0.22 | — 0 37 | — 0.15 |
| μ Ursæ maj. | 12 | 85 53 46.42 | 11 38 53 | + 7.02 | 11 31 51 | 36 | 3.65335 | 58.13204 | 11 31.95 | + 0.44 | — 0.62 | — 0.18 |
| ι Andromedæ | 6 | 86 6 22.45 | 12 6.71 | + 7.41 | 11 59.30 | 43 | 3.63706 | 58.13029 | 11 59.38 | + 0.08 | — 0.14 | — 0.06 |
| γ Andromedæ | 14 | 86 53 26.64 | 14 11.52 | + 10.42 | 14 1.10 | 55 | 3.61333 | 58.12594 | 14 0.29 | — 0.81 | + 0.84 | + 0.03 |
| ο Andromedæ | 6 | 86 58 29.91 | 14 27 05 | + 11 32 | 14 15.73 | 43½ | 3.62255 | 58 12617 | 14 15.27 | — 0.46 | — 0.13 | — 0.59 |

## TABLE II.

| Star. | No. Obs. | Observed Zenith Distance. | Mean Refraction. | Error from Observ. | Mean Refrac, correc | Mean Therm. | $y$ the coeff. of $r$. | $x$ the Refrac at 45°. | Tang $\overline{x-yr}$ X $x$. | Error. | Therm. correct. | Final Error. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| β Bootis | 10 | 87 8 19 70 | 14 58.62 | + 12.30 | 14 46.32 | 34 | 3.59582 | 58″.132967 | 14 47 49 | + 1.17 | — 0.98 | + 0.19 |
| η Aurigæ | 11 | 87 19 9.83 | 15 35 64 | + 7.24 | 15 28.40 | 60 | 3.54576 | | 15 25.91 | — 2.49 | + 1 40 | — 1.09 |
| Aurigæ | 15 | 87 29 7.86 | 16 11.89 | + 6.18 | 16 5.71 | 57 | 3.49971 | | 16 3.85 | — 1 86 | + 1.16 | — 0.70 |
| Persei | 16 | 88 1 0.03 | 18 23.73 | — 2.41 | 18 26 14 | 54 | 3.35247 | | 18 24.77 | — 1.37 | + 1 00 | — 0.37 |
| γ Cygni | 5 | 88 31 1.12 | 20 53 78 | — 16.0 | 21 9 78 | 39 | 3.21379 | | 21 11.37 | + 1.59 | — 0.76 | + 0.83 |
| Persei | 5 | 88 42 35.53 | 21 59.32 | — 28.78 | 22 28 10 | 53 | 3.16032 | | 22 26.48 | — 1.62 | + 1.08 | — 0.54 |

## Mean Refraction.

| Zen. dis. | French tables. | S. G. | Value of *y*. |
|---|---|---|---|
| ° | ′ ″ | ′ ″ | |
| 80 | 5 19.8 | 5 19.18 | 3.63429 |
| 81 | 5 53.5 | 5 52.83 | —— |
| 82 | 6 34.4 | 6 33.79 | —— |
| 83 | 7 24.7 | 7 24.63 | —— |
| 84 | 8 29.9 | 8 29.13 | —— |
| 85 | 9 54.3 | 9 53.03 | —— |
| 86 | 11 48.3 | 11 45.27 | —— |
| 87 | 14 28.1 | 14 19.80 | 3.63429 |
| 88 | 18 22.2 | 18 19.83 | 3.35709 |
| 89 | 24 21.2 | 24 32.94 | 3.07989 |
| 90 | 33 46.3 | 34 28.13 | 2.80269 |

## The two formulæ compared.

| Zen. dis. | $3.3625r \times 58''.1192$ | $3.63429r \times 58''.132967$ |
|---|---|---|
| ° | ′ ″ | ′ ″ |
| 70 | 2 38.41 | 2 38.34 |
| 71 | 2 47.31 | 2 47.23 |
| 72 | 2 57.13 | 2 57.03 |
| 73 | 3 8.04 | 3 7.92 |
| 74 | 3 20.22 | 3 20.07 |
| 75 | 3 33.92 | 3 33.73 |
| 76 | 3 49.44 | 3 49.21 |
| 77 | 4 7.19 | 4 6.89 |
| 78 | 4 27.68 | 4 27.30 |
| 79 | 4 51.59 | 4 51.09 |
| 80 | 5 19.85 | 5 19.18 |
| 81 | 5 53.74 | 5 52.83 |
| 82 | 6 35.06 | 6 33.79 |
| 83 | 7 26.46 | 7 24.63 |
| 84 | 8 31.85 | 8 29.13 |
| 85 | 9 57.27 | 9 53.03 |
| 86 | 11 52.21 | 11 45.27 |
| 87 | 14 31.75 | 14 19.80 |
| 88 | 18 19.19 | 18 19.83 |

# Mean Refraction calculated at 58″,132967 for 45 Degrees of apparent Zenith Distanc

| Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ |
| 0 0 | 0 0.00 | 0.17 | 9 0 | 0 9.20 | 0.17 | 18 0 | 0 18.86 | 0.19 | 27 0 | 0 29.58 | 0.22 | 36 0 | 0 42.17 | 0.26 | 45 0 | 0 58.01 | 0.34 |
| 10 | 0 0.17 | 0.17 | 10 | 0 9.37 | 0.17 | 10 | 0 19.05 | 0.19 | 10 | 0 29.80 | 0.20 | 10 | 0 42.43 | 0.26 | 10 | 0 58.35 | 0.34 |
| 20 | 0 0.34 | 0.17 | 20 | 0 9.54 | 0.18 | 20 | 0 19.24 | 0.19 | 20 | 0 30.00 | 0.22 | 20 | 0 42.69 | 0.26 | 20 | 0 58.69 | 0.34 |
| 30 | 0 0.51 | 0.17 | 30 | 0 9.72 | 0.17 | 30 | 0 19.43 | 0.18 | 30 | 0 30.22 | 0.22 | 30 | 0 42.95 | 0.26 | 30 | 0 59.03 | 0.35 |
| 40 | 0 0.68 | 0.16 | 40 | 0 9.89 | 0.17 | 40 | 0 19.61 | 0.19 | 40 | 0 30.44 | 0.21 | 40 | 0 43.21 | 0.26 | 40 | 0 59.38 | 0.34 |
| 50 | 0 0.84 | 0.17 | 50 | 0 10.06 | 0.18 | 50 | 0 19.80 | 0.19 | 50 | 0 30.65 | 0.22 | 50 | 0 43.47 | 0.27 | 50 | 0 59.72 | 0.35 |
| 1 0 | 0 1.01 | 0.17 | 10 0 | 0 10.24 | 0.17 | 19 0 | 0 19.99 | 0.19 | 28 0 | 0 30.87 | 0.22 | 37 0 | 0 43.74 | 0.26 | 46 0 | 1 0.07 | 0.35 |
| 10 | 0 1.18 | 0.17 | 10 | 0 10.41 | 0.18 | 10 | 0 20.18 | 0.19 | 10 | 0 31.09 | 0.21 | 10 | 0 44.00 | 0.27 | 10 | 1 0.42 | 0.35 |
| 20 | 0 1.35 | 0.17 | 20 | 0 10.59 | 0.17 | 20 | 0 20.37 | 0.19 | 20 | 0 31.30 | 0.22 | 20 | 0 44.27 | 0.26 | 20 | 1 0.77 | 0.36 |
| 30 | 0 1.52 | 0.17 | 30 | 0 10.76 | 0.18 | 30 | 0 20.56 | 0.19 | 30 | 0 31.52 | 0.22 | 30 | 0 44.53 | 0.27 | 30 | 1 1.13 | 0.35 |
| 40 | 0 1.69 | 0.17 | 40 | 0 10.94 | 0.17 | 40 | 0 20.75 | 0.19 | 40 | 0 31.74 | 0.22 | 40 | 0 44.80 | 0.27 | 40 | 1 1.48 | 0.36 |
| 50 | 0 1.86 | 0.17 | 50 | 0 11.11 | 0.18 | 50 | 0 20.94 | 0.19 | 50 | 0 31.96 | 0.22 | 50 | 0 45.07 | 0.27 | 50 | 1 1.84 | 0.36 |
| 2 0 | 0 2.03 | 0.17 | 11 0 | 0 11.29 | 0.17 | 20 0 | 0 21.13 | 0.19 | 29 0 | 0 32.18 | 0.22 | 38 0 | 0 45.34 | 0.28 | 47 0 | 1 2.20 | 0.37 |
| 10 | 0 2.20 | 0.17 | 10 | 0 11.46 | 0.18 | 10 | 0 21.32 | 0.19 | 10 | 0 32.40 | 0.22 | 10 | 0 45.62 | 0.27 | 10 | 1 2.57 | 0.36 |
| 20 | 0 2.37 | 0.16 | 20 | 0 11.64 | 0.17 | 20 | 0 21.51 | 0.20 | 20 | 0 32.62 | 0.23 | 20 | 0 45.89 | 0.27 | 20 | 1 2.93 | 0.37 |
| 30 | 0 2.53 | 0.17 | 30 | 0 11.81 | 0.18 | 30 | 0 21.71 | 0.19 | 30 | 0 32.85 | 0.22 | 30 | 0 46.16 | 0.28 | 30 | 1 3.30 | 0.37 |
| 40 | 0 2.70 | 0.17 | 40 | 0 11.99 | 0.18 | 40 | 0 21.90 | 0.19 | 40 | 0 33.07 | 0.22 | 40 | 0 46.44 | 0.28 | 40 | 1 3.67 | 0.37 |
| 50 | 0 2.87 | 0.17 | 50 | 0 12.17 | 0.17 | 50 | 0 22.09 | 0.20 | 50 | 0 33.29 | 0.23 | 50 | 0 46.72 | 0.28 | 50 | 1 4.04 | 0.37 |
| 3 0 | 0 3.04 | 0.17 | 12 0 | 0 12.34 | 0.18 | 21 0 | 0 22.29 | 0.19 | 30 0 | 0 33.52 | 0.22 | 39 0 | 0 47.00 | 0.28 | 48 0 | 1 4.41 | 0.38 |
| 10 | 0 3.21 | 0.17 | 10 | 0 12.52 | 0.18 | 10 | 0 22.48 | 0.19 | 10 | 0 33.74 | 0.23 | 10 | 0 47.28 | 0.28 | 10 | 1 4.79 | 0.38 |
| 20 | 0 3.38 | 0.17 | 20 | 0 12.70 | 0.17 | 20 | 0 22.67 | 0.20 | 20 | 0 33.97 | 0.23 | 20 | 0 47.56 | 0.28 | 20 | 1 5.17 | 0.38 |
| 30 | 0 3.55 | 0.17 | 30 | 0 12.87 | 0.18 | 30 | 0 22.87 | 0.19 | 30 | 0 34.20 | 0.22 | 30 | 0 47.84 | 0.28 | 30 | 1 5.55 | 0.39 |
| 40 | 0 3.72 | 0.17 | 40 | 0 13.05 | 0.17 | 40 | 0 23.06 | 0.20 | 40 | 0 34.42 | 0.23 | 40 | 0 48.12 | 0.29 | 40 | 1 5.94 | 0.39 |
| 50 | 0 3.89 | 0.17 | 50 | 0 13.22 | 0.18 | 50 | 0 23.26 | 0.20 | 50 | 0 34.65 | 0.23 | 50 | 0 48.41 | 0.28 | 50 | 1 6.33 | 0.39 |
| 4 0 | 0 4.06 | 0.17 | 13 0 | 0 13.40 | 0.18 | 22 0 | 0 23.46 | 0.19 | 31 0 | 0 34.88 | 0.23 | 40 0 | 0 48.69 | 0.29 | 49 0 | 1 6.72 | 0.39 |
| 10 | 0 4.23 | 0.17 | 10 | 0 13.58 | 0.18 | 10 | 0 23.65 | 0.20 | 10 | 0 35.11 | 0.23 | 10 | 0 48.98 | 0.29 | 10 | 1 7.11 | 0.39 |
| 20 | 0 4.40 | 0.17 | 20 | 0 13.76 | 0.18 | 20 | 0 23.85 | 0.20 | 20 | 0 35.34 | 0.23 | 20 | 0 49.27 | 0.29 | 20 | 1 7.50 | 0.40 |
| 30 | 0 4.57 | 0.17 | 30 | 0 13.94 | 0.18 | 30 | 0 24.05 | 0.20 | 30 | 0 35.57 | 0.24 | 30 | 0 49.56 | 0.29 | 30 | 1 7.90 | 0.40 |
| 40 | 0 4.74 | 0.17 | 40 | 0 14.12 | 0.18 | 40 | 0 24.25 | 0.20 | 40 | 0 35.81 | 0.23 | 40 | 0 49.85 | 0.30 | 40 | 1 8.30 | 0.40 |
| 50 | 0 4.91 | 0.17 | 50 | 0 14.30 | 0.18 | 50 | 0 24.45 | 0.20 | 50 | 0 36.04 | 0.23 | 50 | 0 50.15 | 0.29 | 50 | 1 8.70 | 0.41 |
| 5 0 | 0 5.08 | 0.17 | 14 0 | 0 14.48 | 0.18 | 23 0 | 0 24.65 | 0.20 | 32 0 | 0 36.27 | 0.24 | 41 0 | 0 50.44 | 0.30 | 50 0 | 1 9.11 | 0.41 |
| 10 | 0 5.25 | 0.17 | 10 | 0 14.66 | 0.18 | 10 | 0 24.85 | 0.20 | 10 | 0 36.51 | 0.23 | 10 | 0 50.74 | 0.30 | 10 | 1 9.52 | 0.41 |
| 20 | 0 5.42 | 0.17 | 20 | 0 14.84 | 0.18 | 20 | 0 25.05 | 0.20 | 20 | 0 36.74 | 0.24 | 20 | 0 51.04 | 0.30 | 20 | 1 9.93 | 0.41 |
| 30 | 0 5.59 | 0.17 | 30 | 0 15.02 | 0.18 | 30 | 0 25.25 | 0.20 | 30 | 0 36.98 | 0.24 | 30 | 0 51.34 | 0.30 | 20 | 1 10.34 | 0.42 |
| 40 | 0 5.76 | 0.17 | 40 | 0 15.20 | 0.18 | 40 | 0 25.45 | 0.20 | 40 | 0 37.22 | 0.24 | 40 | 0 51.64 | 0.30 | 40 | 1 10.76 | 0.42 |
| 50 | 0 5.93 | 0.17 | 50 | 0 15.38 | 0.18 | 50 | 0 25.65 | 0.20 | 50 | 0 37.46 | 0.24 | 50 | 0 51.94 | 0.31 | 50 | 1 11.18 | 0.42 |
| 6 0 | 0 6.10 | 0.17 | 15 0 | 0 15.56 | 0.18 | 24 0 | 0 25.85 | 0.20 | 33 0 | 0 37.70 | 0.24 | 42 0 | 0 52.25 | 0.30 | 51 0 | 1 11.60 | 0.43 |
| 10 | 0 6.27 | 0.17 | 10 | 0 15.74 | 0.18 | 10 | 0 26.05 | 0.21 | 10 | 0 37.94 | 0.24 | 10 | 0 52.55 | 0.31 | 10 | 1 12.03 | 0.43 |
| 20 | 0 6.44 | 0.18 | 20 | 0 15.92 | 0.18 | 20 | 0 26.26 | 0.20 | 20 | 0 38.18 | 0.24 | 20 | 0 52.86 | 0.31 | 20 | 1 12.46 | 0.43 |
| 30 | 0 6.62 | 0.17 | 30 | 0 16.10 | 0.18 | 30 | 0 26.46 | 0.20 | 30 | 0 38.42 | 0.24 | 30 | 0 53.17 | 0.31 | 30 | 1 12.89 | 0.44 |
| 40 | 0 6.79 | 0.17 | 40 | 0 16.28 | 0.19 | 40 | 0 26.66 | 0.21 | 40 | 0 38.66 | 0.25 | 40 | 0 53.48 | 0.31 | 40 | 1 13.33 | 0.44 |
| 50 | 0 6.96 | 0.17 | 50 | 0 16.47 | 0.18 | 50 | 0 26.87 | 0.20 | 50 | 0 38.91 | 0.24 | 50 | 0 53.79 | 0.32 | 50 | 1 13.77 | 0.44 |
| 7 0 | 0 7.13 | 0.17 | 16 0 | 0 16.65 | 0.18 | 25 0 | 0 27.07 | 0.21 | 34 0 | 0 39.15 | 0.25 | 43 0 | 0 54.11 | 0.31 | 52 0 | 1 14.21 | 0.44 |
| 10 | 0 7.30 | 0.17 | 10 | 0 16.83 | 0.18 | 10 | 0 27.28 | 0.21 | 10 | 0 39.40 | 0.24 | 10 | 0 54.42 | 0.32 | 10 | 1 14.65 | 0.45 |
| 20 | 0 7.47 | 0.17 | 20 | 0 17.01 | 0.19 | 20 | 0 27.49 | 0.20 | 20 | 0 39.64 | 0.25 | 20 | 0 54.74 | 0.32 | 20 | 1 15.10 | 0.45 |
| 30 | 0 7.64 | 0.18 | 30 | 0 17.20 | 0.18 | 30 | 0 27.69 | 0.21 | 30 | 0 39.89 | 0.25 | 30 | 0 55.06 | 0.32 | 30 | 1 15.55 | 0.46 |
| 40 | 0 7.82 | 0.17 | 40 | 0 17.38 | 0.19 | 40 | 0 27.90 | 0.21 | 40 | 0 40.14 | 0.25 | 40 | 0 55.38 | 0.32 | 40 | 1 16.01 | 0.46 |
| 50 | 0 7.99 | 0.17 | 50 | 0 17.57 | 0.18 | 50 | 0 28.11 | 0.21 | 50 | 0 40.39 | 0.25 | 50 | 0 55.70 | 0.33 | 50 | 1 16.47 | 0.46 |
| 8 0 | 0 8.16 | 0.17 | 17 0 | 0 17.75 | 0.19 | 26 0 | 0 28.32 | 0.21 | 35 0 | 0 40.64 | 0.25 | 44 0 | 0 56.03 | 0.32 | 53 0 | 1 16.93 | 0.46 |
| 10 | 0 8.33 | 0.17 | 10 | 0 17.94 | 0.18 | 10 | 0 28.53 | 0.21 | 10 | 0 40.89 | 0.26 | 10 | 0 56.35 | 0.33 | 10 | 1 17.39 | 0.47 |
| 20 | 0 8.50 | 0.18 | 20 | 0 18.12 | 0.19 | 20 | 0 28.74 | 0.21 | 20 | 0 41.15 | 0.25 | 20 | 0 56.68 | 0.33 | 20 | 1 17.86 | 0.47 |
| 30 | 0 8.68 | 0.17 | 30 | 0 18.31 | 0.18 | 30 | 0 28.95 | 0.21 | 30 | 0 41.40 | 0.26 | 30 | 0 57.01 | 0.33 | 30 | 1 18.33 | 0.48 |
| 40 | 0 8.85 | 0.17 | 40 | 0 18.49 | 0.19 | 40 | 0 29.16 | 0.21 | 40 | 0 41.66 | 0.25 | 40 | 0 57.34 | 0.34 | 40 | 1 18.81 | 0.48 |
| 50 | 0 9.02 | 0.18 | 50 | 0 18.68 | 0.18 | 50 | 0 29.37 | 0.21 | 50 | 0 41.91 | 0.26 | 50 | 0 57.68 | 0.33 | 50 | 1 19.29 | 0.49 |

7 for 45 Degrees of apparent Zenith Distance × Tang. $\overline{Z - 3.6342956r}$ so far as 87° Zen. Dis. below wh

| Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ |
| 0 29.58 | 0.22 | 36 0 | 0 42.17 | 0.26 | 45 0 | 0 58.01 | 0.34 | 54 0 | 1 19.78 | 0.49 | 63 0 | 1 53.53 | 0.82 | 71 0 | 2 47.23 | 0.78 | 75 30 | 3 41.22 | 1. |
| 0 29.80 | 0.20 | 10 | 0 42.43 | 0.26 | 10 | 0 58.35 | 0.34 | 10 | 1 20.27 | 0.49 | 10 | 1 54.35 | 0.82 | 5 | 2 48.01 | 0.79 | 35 | 3 42.52 | 1. |
| 0 30.00 | 0.22 | 20 | 0 42.69 | 0.26 | 20 | 0 58.69 | 0.34 | 20 | 1 20.76 | 0.49 | 20 | 1 55.17 | 0.83 | 10 | 2 48.80 | 0.79 | 40 | 3 43.83 | 1. |
| 0 30.22 | 0.22 | 30 | 0 42.95 | 0.26 | 30 | 0 59.03 | 0.35 | 30 | 1 21.25 | 0.50 | 30 | 1 56.00 | 0.85 | 15 | 2 49.59 | 0.80 | 45 | 3 45.15 | 1. |
| 0 30.44 | 0.21 | 40 | 0 43.21 | 0.26 | 40 | 0 59.38 | 0.34 | 40 | 1 21.75 | 0.51 | 40 | 1 56.85 | 0.85 | 20 | 2 50.39 | 0.81 | 50 | 3 46.49 | 1. |
| 0 30.65 | 0.22 | 50 | 0 43.47 | 0.27 | 50 | 0 59.72 | 0.35 | 50 | 1 22.26 | 0.51 | 50 | 1 57.70 | 0.86 | 25 | 2 51.20 | 0.81 | 55 | 3 47.84 | 1. |
| 0 30.87 | 0.22 | 37 0 | 0 43.74 | 0.26 | 46 0 | 1 0.07 | 0.35 | 55 0 | 1 22.77 | 0.51 | 64 0 | 1 58.56 | 0.87 | 30 | 2 52.01 | 0.82 | 76 0 | 3 49.21 | 1. |
| 0 31.09 | 0.21 | 10 | 0 44.00 | 0.27 | 10 | 1 0.42 | 0.35 | 10 | 1 23.28 | 0.51 | 10 | 1 59.43 | 0.89 | 35 | 2 52.83 | 0.82 | 5 | 3 50.59 | 1. |
| 0 31.30 | 0.22 | 20 | 0 44.27 | 0.26 | 20 | 1 0.77 | 0.36 | 20 | 1 23.79 | 0.52 | 20 | 2 0.32 | 0.89 | 40 | 2 53.65 | 0.84 | 10 | 3 51.99 | 1. |
| 0 31.52 | 0.22 | 30 | 0 44.53 | 0.27 | 30 | 1 1.13 | 0.35 | 30 | 1 24.31 | 0.53 | 30 | 2 1.21 | 0.91 | 45 | 2 54.49 | 0.84 | 15 | 3 53.41 | 1. |
| 0 31.74 | 0.22 | 40 | 0 44.80 | 0.27 | 40 | 1 1.48 | 0.36 | 40 | 1 24.84 | 0.53 | 40 | 2 2.12 | 0.91 | 50 | 2 55.33 | 0.85 | 20 | 3 54.84 | 1. |
| 0 31.96 | 0.22 | 50 | 0 45.07 | 0.27 | 50 | 1 1.84 | 0.36 | 50 | 1 25.37 | 0.54 | 50 | 2 3.03 | 0.93 | 55 | 2 56.18 | 0.85 | 25 | 3 56.29 | 1. |
| 0 32.18 | 0.22 | 38 0 | 0 45.34 | 0.28 | 47 0 | 1 2.20 | 0.37 | 56 0 | 1 25.91 | 0.54 | 65 0 | 2 3.96 | 0.94 | 72 0 | 2 57.03 | 0.86 | 30 | 3 57.75 | 1. |
| 0 32.40 | 0.22 | 10 | 0 45.62 | 0.27 | 10 | 1 2.57 | 0.36 | 10 | 1 26.45 | 0.54 | 10 | 2 4.90 | 0.95 | 5 | 2 57.89 | 0.87 | 35 | 3 59.23 | 1. |
| 0 32.62 | 0.23 | 20 | 0 45.89 | 0.27 | 20 | 1 2.93 | 0.37 | 20 | 1 26.99 | 0.55 | 20 | 2 5.85 | 0.96 | 10 | 2 58.76 | 0.88 | 40 | 4 0.73 | 1. |
| 0 32.85 | 0.22 | 30 | 0 46.16 | 0.28 | 30 | 1 3.30 | 0.37 | 30 | 1 27.54 | 0.55 | 30 | 2 6.81 | 0.97 | 15 | 2 59.64 | 0.89 | 45 | 4 2.25 | 1. |
| 0 33.07 | 0.22 | 40 | 0 46.44 | 0.28 | 40 | 1 3.67 | 0.37 | 40 | 1 28.09 | 0.56 | 40 | 2 7.78 | 0.99 | 20 | 3 0.53 | 0.90 | 50 | 4 3.78 | 1. |
| 0 33.29 | 0.23 | 50 | 0 46.72 | 0.28 | 50 | 1 4.04 | 0.37 | 50 | 1 28.65 | 0.56 | 50 | 2 8.77 | 1.00 | 25 | 3 1.43 | 0.90 | 55 | 4 5.33 | 1. |
| 0 33.52 | 0.22 | 39 0 | 0 47.00 | 0.28 | 48 0 | 1 4.41 | 0.38 | 57 0 | 1 29.21 | 0.57 | 66 0 | 2 9.77 | 1.01 | 30 | 3 2.33 | 0.91 | 77 0 | 4 6.89 | 1. |
| 0 33.74 | 0.23 | 10 | 0 47.28 | 0.28 | 10 | 1 4.79 | 0.38 | 10 | 1 29.78 | 0.57 | 10 | 2 10.78 | 1.03 | 35 | 3 3.24 | 0.92 | 5 | 4 8.48 | 1. |
| 0 33.97 | 0.23 | 20 | 0 47.56 | 0.28 | 20 | 1 5.17 | 0.38 | 20 | 1 30.35 | 0.58 | 20 | 2 11.81 | 1.04 | 40 | 3 4.16 | 0.93 | 10 | 4 10.09 | 1. |
| 0 34.20 | 0.22 | 30 | 0 47.84 | 0.28 | 30 | 1 5.55 | 0.39 | 30 | 1 30.93 | 0.58 | 30 | 2 12.85 | 1.05 | 45 | 3 5.09 | 0.93 | 15 | 4 11.72 | 1. |
| 0 34.42 | 0.23 | 40 | 0 48.12 | 0.29 | 40 | 1 5.94 | 0.39 | 40 | 1 31.51 | 0.59 | 40 | 2 13.90 | 1.07 | 50 | 3 6.02 | 0.95 | 20 | 4 13.37 | 1. |
| 0 34.65 | 0.23 | 50 | 0 48.41 | 0.28 | 50 | 1 6.33 | 0.39 | 50 | 1 32.10 | 0.59 | 50 | 2 14.97 | 1.08 | 55 | 3 6.97 | 0.95 | 25 | 4 15.03 | 1. |
| 0 34.88 | 0.23 | 40 0 | 0 48.69 | 0.29 | 49 0 | 1 6.72 | 0.39 | 58 0 | 1 32.69 | 0.60 | 67 0 | 2 16.05 | 1.09 | 73 0 | 3 7.92 | 0.96 | 30 | 4 16.72 | 1. |
| 0 35.11 | 0.23 | 10 | 0 48.98 | 0.29 | 10 | 1 7.11 | 0.39 | 10 | 1 33.29 | 0.61 | 10 | 2 17.14 | 1.11 | 5 | 3 8.88 | 0.97 | 35 | 4 18.43 | 1. |
| 0 35.34 | 0.23 | 20 | 0 49.27 | 0.29 | 20 | 1 7.50 | 0.40 | 20 | 1 33.90 | 0.61 | 20 | 2 18.25 | 1.13 | 10 | 3 9.85 | 0.98 | 40 | 4 20.16 | 1. |
| 0 35.57 | 0.24 | 30 | 0 49.56 | 0.29 | 30 | 1 7.90 | 0.40 | 30 | 1 34.51 | 0.62 | 30 | 2 19.38 | 1.14 | 15 | 3 10.83 | 0.99 | 45 | 4 21.91 | 1. |
| 0 35.81 | 0.23 | 40 | 0 49.85 | 0.30 | 40 | 1 8.30 | 0.40 | 40 | 1 35.13 | 0.62 | 40 | 2 20.52 | 1.16 | 20 | 3 11.82 | 1.00 | 50 | 4 23.68 | 1. |
| 0 36.04 | 0.23 | 50 | 0 50.15 | 0.29 | 50 | 1 8.70 | 0.41 | 50 | 1 35.75 | 0.63 | 50 | 2 21.68 | 1.17 | 25 | 3 12.82 | 1.00 | 55 | 4 25.48 | 1. |
| 0 36.27 | 0.24 | 41 0 | 0 50.44 | 0.30 | 50 0 | 1 9.11 | 0.41 | 59 0 | 1 36.38 | 0.63 | 68 0 | 2 22.85 | 1.19 | 30 | 3 13.82 | 1.02 | 78 0 | 4 27.30 | 1. |
| 0 36.51 | 0.23 | 10 | 0 50.74 | 0.30 | 10 | 1 9.52 | 0.41 | 10 | 1 37.01 | 0.64 | 10 | 2 24.04 | 1.21 | 35 | 3 14.84 | 1.02 | 5 | 4 29.14 | 1. |
| 0 36.74 | 0.24 | 20 | 0 51.04 | 0.30 | 20 | 1 9.93 | 0.41 | 20 | 1 37.65 | 0.65 | 20 | 2 25.25 | 1.22 | 40 | 3 15.86 | 1.04 | 10 | 4 31.01 | 1. |
| 0 36.98 | 0.24 | 30 | 0 51.34 | 0.30 | 20 | 1 10.34 | 0.42 | 30 | 1 38.30 | 0.65 | 30 | 2 26.47 | 1.24 | 45 | 3 16.90 | 1.05 | 15 | 4 32.90 | 1. |
| 0 37.22 | 0.24 | 40 | 0 51.64 | 0.30 | 40 | 1 10.76 | 0.42 | 40 | 1 38.95 | 0.66 | 40 | 2 27.71 | 1.26 | 50 | 3 17.95 | 1.06 | 20 | 4 34.81 | 1. |
| 0 37.46 | 0.24 | 50 | 0 51.94 | 0.31 | 50 | 1 11.18 | 0.42 | 50 | 1 39.61 | 0.67 | 50 | 2 28.97 | 1.28 | 55 | 3 19.01 | 1.06 | 25 | 4 36.75 | 1. |
| 0 37.70 | 0.24 | 42 0 | 0 52.25 | 0.30 | 51 0 | 1 11.60 | 0.43 | 60 0 | 1 40.28 | 0.67 | 69 0 | 2 30.25 | 1.30 | 74 0 | 3 20.07 | 1.08 | 30 | 4 38.72 | 1. |
| 0 37.94 | 0.24 | 10 | 0 52.55 | 0.31 | 10 | 1 12.03 | 0.43 | 10 | 1 40.95 | 0.68 | 10 | 2 31.55 | 1.32 | 5 | 3 21.15 | 1.08 | 35 | 4 40.71 | 2 |
| 0 38.18 | 0.24 | 20 | 0 52.86 | 0.31 | 20 | 1 12.46 | 0.43 | 20 | 1 41.63 | 0.69 | 20 | 2 32.87 | 1.34 | 10 | 3 22.23 | 1.10 | 40 | 4 42.73 | 2 |
| 0 38.42 | 0.24 | 30 | 0 53.17 | 0.31 | 30 | 1 12.89 | 0.44 | 30 | 1 42.32 | 0.69 | 30 | 2 34.21 | 1.35 | 15 | 3 23.33 | 1.11 | 45 | 4 44.78 | 2 |
| 0 38.66 | 0.25 | 40 | 0 53.48 | 0.31 | 40 | 1 13.33 | 0.44 | 40 | 1 43.01 | 0.70 | 40 | 2 35.56 | 1.38 | 20 | 3 24.44 | 1.12 | 50 | 4 46.85 | 2 |
| 0 38.91 | 0.24 | 50 | 0 53.79 | 0.32 | 50 | 1 13.77 | 0.44 | 50 | 1 43.71 | 0.71 | 50 | 2 36.94 | 1.40 | 25 | 3 25.56 | 1.13 | 55 | 4 48.96 | 2 |
| 0 39.15 | 0.25 | 43 0 | 0 54.11 | 0.31 | 52 0 | 1 14.21 | 0.44 | 61 0 | 1 44.42 | 0.72 | 70 0 | 2 38.34 | 0.71 | 30 | 3 26.69 | 1.15 | 79 0 | 4 51.09 | 2 |
| 0 39.40 | 0.24 | 10 | 0 54.42 | 0.32 | 10 | 1 14.65 | 0.45 | 10 | 1 45.14 | 0.72 | 5 | 2 39.05 | 0.71 | 35 | 3 27.84 | 1.15 | 5 | 4 53.25 | 2 |
| 0 39.64 | 0.25 | 20 | 0 54.74 | 0.32 | 20 | 1 15.10 | 0.45 | 20 | 1 45.86 | 0.73 | 10 | 2 39.76 | 0.72 | 40 | 3 28.99 | 1.17 | 10 | 4 55.44 | 2 |
| 0 39.89 | 0.25 | 30 | 0 55.06 | 0.32 | 30 | 1 15.55 | 0.46 | 30 | 1 46.59 | 0.74 | 15 | 2 40.48 | 0.73 | 45 | 3 30.16 | 1.18 | 15 | 4 57.67 | 2 |
| 0 40.14 | 0.25 | 40 | 0 55.38 | 0.32 | 40 | 1 16.01 | 0.46 | 40 | 1 47.33 | 0.75 | 20 | 2 41.21 | 0.73 | 50 | 3 31.34 | 1.19 | 20 | 4 59.92 | 2 |
| 0 40.39 | 0.25 | 50 | 0 55.70 | 0.33 | 50 | 1 16.47 | 0.46 | 50 | 1 48.08 | 0.75 | 25 | 2 41.94 | 0.74 | 55 | 3 32.53 | 1.20 | 25 | 5 2.21 | 2 |
| 0 40.64 | 0.25 | 44 0 | 0 56.03 | 0.32 | 53 0 | 1 16.93 | 0.46 | 62 0 | 1 48.83 | 0.76 | 30 | 2 42.68 | 0.74 | 75 0 | 3 33.73 | 1.22 | 30 | 5 4.53 | 2 |
| 0 40.89 | 0.26 | 10 | 0 56.35 | 0.33 | 10 | 1 17.39 | 0.47 | 10 | 1 49.59 | 0.77 | 35 | 2 43.42 | 0.75 | 5 | 3 34.95 | 1.23 | 35 | 5 6.88 | 2 |
| 0 41.15 | 0.25 | 20 | 0 56.68 | 0.33 | 20 | 1 17.86 | 0.47 | 20 | 1 50.36 | 0.78 | 40 | 2 44.17 | 0.76 | 10 | 3 36.18 | 1.24 | 40 | 5 9.27 | 2 |
| 0 41.40 | 0.26 | 30 | 0 57.01 | 0.33 | 30 | 1 18.33 | 0.48 | 30 | 1 51.14 | 0.79 | 45 | 2 44.93 | 0.76 | 15 | 3 37.42 | 1.25 | 45 | 5 11.69 | 2 |
| 0 41.66 | 0.25 | 40 | 0 57.34 | 0.34 | 40 | 1 18.81 | 0.48 | 40 | 1 51.93 | 0.80 | 50 | 2 45.69 | 0.77 | 20 | 3 38.67 | 1.27 | 50 | 5 14.15 | 2 |
| 0 41.91 | 0.26 | 50 | 0 57.68 | 0.33 | 50 | 1 19.29 | 0.49 | 50 | 1 52.73 | 0.80 | 55 | 2 46.46 | 0.77 | 25 | 3 39.94 | 1.28 | 55 | 5 16.65 | 2 |

3.6342956r so far as 87° Zen. Dis. below which *r* is reduced, 00462 for each minute.



| Zen. Dis. | Refrac. | Diff. | Zen Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. | Zen. Dis. | Refrac. | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ | ° ′ | ′ ″ | ″ |
| 3 0 | 1 53.53 | 0.82 | 71 0 | 2 47.23 | 0.78 | 75 30 | 3 41.22 | 1.30 | 80 0 | 5 19.18 | 2.57 | 84 30 | 9 8.18 | 7.05 | 88 18 | 19 54.47 | 17.06 |
| 10 | 1 54.35 | 0.82 | 5 | 2 48.01 | 0.79 | 35 | 3 42.52 | 1.31 | 5 | 5 21.75 | 2.61 | 35 | 9 15.23 | 7.20 | 21 | 20 11.53 | 17.45 |
| 20 | 1 55.17 | 0.83 | 10 | 2 48.80 | 0.79 | 40 | 3 43.83 | 1.32 | 10 | 5 24.36 | 2.65 | 40 | 9 22.43 | 7.38 | 24 | 20 28.98 | 17.84 |
| 30 | 1 56.00 | 0.85 | 15 | 2 49.59 | 0.80 | 45 | 3 45.15 | 1.34 | 15 | 5 27.01 | 2.70 | 45 | 9 29.81 | 7.56 | 27 | 20 46.82 | 18.26 |
| 40 | 1 56.85 | 0.85 | 20 | 2 50.39 | 0.81 | 50 | 3 46.49 | 1.35 | 20 | 5 29.71 | 2.73 | 50 | 9 37.37 | 7.73 | 30 | 21 5.08 | 18.68 |
| 50 | 1 57.70 | 0.86 | 25 | 2 51.20 | 0.81 | 55 | 3 47.84 | 1.37 | 25 | 5 32.44 | 2.77 | 55 | 9 45.10 | 7.93 | 33 | 21 23.76 | 19.12 |
| 4 0 | 1 58.56 | 0.87 | 30 | 2 52.01 | 0.82 | 76 0 | 3 49.21 | 1.38 | 30 | 5 35.21 | 2.82 | 85 0 | 9 53.03 | 8.12 | 36 | 21 42.88 | 19.57 |
| 10 | 1 59.43 | 0.89 | 35 | 2 52.83 | 0.82 | 5 | 3 50.59 | 1.40 | 35 | 5 38.03 | 2.87 | 5 | 10 1.15 | 8.31 | 39 | 22 2.45 | 20.02 |
| 20 | 2 0.32 | 0.89 | 40 | 2 53.65 | 0.84 | 10 | 3 51.99 | 1.42 | 40 | 5 40.90 | 2.91 | 10 | 10 9.46 | 8.53 | 42 | 22 22.47 | 20.49 |
| 30 | 2 1.21 | 0.91 | 45 | 2 54.49 | 0.84 | 15 | 3 53.41 | 1.43 | 45 | 5 43.81 | 2.96 | 15 | 10 17.99 | 8.74 | 45 | 22 42.96 | 20.99 |
| 40 | 2 2.12 | 0.91 | 50 | 2 55.33 | 0.85 | 20 | 3 54.84 | 1.45 | 50 | 5 46.77 | 3.01 | 20 | 10 26.73 | 8.96 | 48 | 23 3.95 | 21.47 |
| 50 | 2 3.03 | 0.93 | 55 | 2 56.18 | 0.85 | 25 | 3 56.29 | 1.46 | 55 | 5 49.78 | 3.05 | 25 | 10 35.69 | 9.19 | 51 | 23 25.42 | 21.98 |
| 5 0 | 2 3.96 | 0.94 | 72 0 | 2 57.03 | 0.86 | 30 | 3 57.75 | 1.48 | 81 0 | 5 52.83 | 3.10 | 30 | 10 44.88 | 9.43 | 54 | 23 47.40 | 22.50 |
| 10 | 2 4.90 | 0.95 | 5 | 2 57.89 | 0.87 | 35 | 3 59.23 | 1.50 | 5 | 5 55.93 | 3.16 | 35 | 10 54.31 | 9.67 | 57 | 24 9.90 | 23.04 |
| 20 | 2 5.85 | 0.96 | 10 | 2 58.76 | 0.88 | 40 | 4 0.73 | 1.52 | 10 | 5 59.09 | 3.21 | 40 | 11 3.98 | 9.92 | 89 0 | 24 32.94 | 15.66 |
| 30 | 2 6.81 | 0.97 | 15 | 2 59.64 | 0.89 | 45 | 4 2.25 | 1.53 | 15 | 6 2.30 | 3.26 | 45 | 11 13.90 | 10.19 | 2 | 24 48.60 | 15.91 |
| 40 | 2 7.78 | 0.99 | 20 | 3 0.53 | 0.90 | 50 | 4 3.78 | 1.55 | 20 | 6 5.56 | 3.32 | 50 | 11 24.09 | 10.45 | 4 | 25 4.51 | 16.16 |
| 50 | 2 8.77 | 1.00 | 25 | 3 1.43 | 0.90 | 55 | 4 5.33 | 1.56 | 25 | 6 8.88 | 3.38 | 55 | 11 34.54 | 10.73 | 6 | 25 20.67 | 16.42 |
| 6 0 | 2 9.77 | 1.01 | 30 | 3 2.33 | 0.91 | 77 0 | 4 6.89 | 1.59 | 30 | 6 12.26 | 3.43 | 86 0 | 11 45.27 | 8.80 | 8 | 25 37.09 | 16.68 |
| 10 | 2 10.78 | 1.03 | 35 | 3 3.24 | 0.92 | 5 | 4 8.48 | 1.61 | 35 | 6 15.69 | 3.50 | 4 | 11 54.07 | 8.99 | 10 | 25 53.77 | 16.94 |
| 20 | 2 11.81 | 1.04 | 40 | 3 4.16 | 0.93 | 10 | 4 10.09 | 1.63 | 40 | 6 19.19 | 3.55 | 8 | 12 3.06 | 9.18 | 12 | 26 10.71 | 17.20 |
| 30 | 2 12.85 | 1.05 | 45 | 3 5.09 | 0.93 | 15 | 4 11.72 | 1.65 | 45 | 6 22.74 | 3.62 | 12 | 12 12.24 | 9.39 | 14 | 26 27.91 | 17.49 |
| 40 | 2 13.90 | 1.07 | 50 | 3 6.02 | 0.95 | 20 | 4 13.37 | 1.66 | 50 | 6 26.36 | 3.68 | 16 | 12 21.63 | 9.59 | 16 | 26 45.40 | 17.76 |
| 50 | 2 14.97 | 1.08 | 55 | 3 6.97 | 0.95 | 25 | 4 15.03 | 1.69 | 55 | 6 30.04 | 3.75 | 20 | 12 31.22 | 9.80 | 18 | 27 3.16 | 18.04 |
| 7 0 | 2 16.05 | 1.09 | 73 0 | 3 7.92 | 0.96 | 30 | 4 16.72 | 1.71 | 82 0 | 6 33.79 | 3.82 | 24 | 12 41.02 | 10.02 | 20 | 27 21.20 | 18.32 |
| 10 | 2 17.14 | 1.11 | 5 | 3 8.88 | 0.97 | 35 | 4 18.43 | 1.73 | 5 | 6 37.61 | 3.89 | 28 | 12 51.04 | 10.24 | 22 | 27 39.52 | 18.62 |
| 20 | 2 18.25 | 1.13 | 10 | 3 9.85 | 0.98 | 40 | 4 20.16 | 1.75 | 10 | 6 41.50 | 3.96 | 32 | 13 1.28 | 10.47 | 24 | 27 58.14 | 18.91 |
| 30 | 2 19.38 | 1.14 | 15 | 3 10.83 | 0.99 | 45 | 4 21.91 | 1.77 | 15 | 6 45.46 | 4.03 | 36 | 13 11.75 | 10.71 | 26 | 28 17.05 | 19.21 |
| 40 | 2 20.52 | 1.16 | 20 | 3 11.82 | 1.00 | 50 | 4 23.68 | 1.80 | 20 | 6 49.49 | 4.10 | 40 | 13 22.46 | 10.96 | 28 | 28 36.26 | 19.52 |
| 50 | 2 21.68 | 1.17 | 25 | 3 12.82 | 1.00 | 55 | 4 25.48 | 1.82 | 25 | 6 53.59 | 4.19 | 44 | 13 33.42 | 11.20 | 30 | 28 55.78 | 19.82 |
| 8 0 | 2 22.85 | 1.19 | 30 | 3 13.82 | 1.02 | 78 0 | 4 27.30 | 1.84 | 30 | 6 57.78 | 4.26 | 48 | 13 44.62 | 11.46 | 32 | 29 15.60 | 20.14 |
| 10 | 2 24.04 | 1.21 | 35 | 3 14.84 | 1.02 | 5 | 4 29.14 | 1.87 | 35 | 7 2.04 | 4.35 | 52 | 13 56.08 | 11.73 | 34 | 29 35.74 | 20.45 |
| 20 | 2 25.25 | 1.22 | 40 | 3 15.86 | 1.04 | 10 | 4 31.01 | 1.89 | 40 | 7 6.39 | 4.43 | 56 | 14 7.81 | 11.99 | 36 | 29 56.19 | 20.78 |
| 30 | 2 26.47 | 1.24 | 45 | 3 16.90 | 1.05 | 15 | 4 32.90 | 1.91 | 45 | 7 10.82 | 4.51 | 87 0 | 14 19.80 | 13.11 | 38 | 30 16.97 | 21.10 |
| 40 | 2 27.71 | 1.26 | 50 | 3 17.95 | 1.06 | 20 | 4 34.81 | 1.94 | 50 | 7 15.33 | 4.60 | 4 | 14 32.91 | 13.46 | 40 | 30 38.07 | 21.44 |
| 50 | 2 28.97 | 1.28 | 55 | 3 19.01 | 1.06 | 25 | 4 36.75 | 1.97 | 55 | 7 19.93 | 4.70 | 8 | 14 46.37 | 13.83 | 42 | 30 59.51 | 21.77 |
| 9 0 | 2 30.25 | 1.30 | 74 0 | 3 20.07 | 1.08 | 30 | 4 38.72 | 1.99 | 83 0 | 7 24.63 | 4.79 | 12 | 15 0.20 | 14.20 | 44 | 31 21.28 | 22.11 |
| 10 | 2 31.55 | 1.32 | 5 | 3 21.15 | 1.08 | 35 | 4 40.71 | 2.02 | 5 | 7 29.42 | 4.88 | 16 | 15 14.40 | 14.60 | 46 | 31 43.39 | 22.46 |
| 20 | 2 32.87 | 1.34 | 10 | 3 22.23 | 1.10 | 40 | 4 42.73 | 2.05 | 10 | 7 34.30 | 4.99 | 20 | 15 29.00 | 15.00 | 48 | 32 5.85 | 22.81 |
| 30 | 2 34.21 | 1.35 | 15 | 3 23.33 | 1.11 | 45 | 4 44.78 | 2.07 | 15 | 7 39.29 | 5.09 | 24 | 15 44.00 | 15.42 | 50 | 32 28.66 | 23.16 |
| 40 | 2 35.56 | 1.38 | 20 | 3 24.44 | 1.12 | 50 | 4 46.85 | 2.11 | 20 | 7 44.38 | 5.19 | 28 | 15 59.42 | 15.85 | 52 | 32 51.82 | 23.53 |
| 50 | 2 36.94 | 1.40 | 25 | 3 25.56 | 1.13 | 55 | 4 48.96 | 2.13 | 25 | 7 49.57 | 5.30 | 32 | 16 15.27 | 16.31 | 54 | 33 15.35 | 23.89 |
| 70 0 | 2 38.34 | 0.71 | 30 | 3 26.69 | 1.15 | 79 0 | 4 51.09 | 2.16 | 30 | 7 54.87 | 5.41 | 36 | 16 31.58 | 16.77 | 56 | 33 39.24 | 24.26 |
| 5 | 2 39.05 | 0.71 | 35 | 3 27.84 | 1.15 | 5 | 4 53.25 | 2.19 | 35 | 8 0.28 | 5.52 | 40 | 16 48.35 | 17.26 | 58 | 34 3.5[illegible] | 24.63 |
| 10 | 2 39.76 | 0.72 | 40 | 3 28.99 | 1.17 | 10 | 4 55.44 | 2.23 | 40 | 8 5.80 | 5.65 | 44 | 17 5.61 | 17.76 | 90 0 | 34 28.13 | 25.02 |
| 15 | 2 40.48 | 0.73 | 45 | 3 30.16 | 1.18 | 15 | 4 57.67 | 2.25 | 45 | 8 11.45 | 5.76 | 48 | 17 23.37 | 18.27 | 2 | 34 53.15 | 25.40 |
| 20 | 2 41.21 | 0.73 | 50 | 3 31.34 | 1.19 | 20 | 4 59.92 | 2.29 | 50 | 8 17.21 | 5.89 | 52 | 17 41.64 | 18.82 | 4 | 35 18.55 | 25.79 |
| 25 | 2 41.94 | 0.74 | 55 | 3 32.53 | 1.20 | 25 | 5 2.21 | 2.32 | 55 | 8 23.10 | 6.03 | 56 | 18 0.46 | 19.37 | 6 | 35 44.34 | 26.18 |
| 30 | 2 42.68 | 0.74 | 75 0 | 3 33.73 | 1.22 | 30 | 5 4.53 | 2.35 | 84 0 | 8 29.13 | 6.15 | 88 0 | 18 19.83 | 14.91 | 8 | 36 10.52 | 26.58 |
| 35 | 2 43.42 | 0.75 | 5 | 3 34.95 | 1.23 | 35 | 5 6.88 | 2.39 | 5 | 8 35.28 | 6.29 | 3 | 18 34.74 | 15.24 | 10 | 36 37.10 | 26.98 |
| 40 | 2 44.17 | 0.76 | 10 | 3 36.18 | 1.24 | 40 | 5 9.27 | 2.42 | 10 | 8 41.57 | 6.43 | 6 | 18 49.98 | 15.59 | 12 | 37 4.08 | 27.39 |
| 45 | 2 44.93 | 0.76 | 15 | 3 37.42 | 1.25 | 45 | 5 11.69 | 2.46 | 15 | 8 48.0. | 6.57 | 9 | 19 5.57 | 15.94 | 14 | 37 31.47 | 27.81 |
| 50 | 2 45.69 | 0.77 | 20 | 3 38.67 | 1.27 | 50 | 5 14.15 | 2.50 | 20 | 8 54.57 | 6.73 | 12 | 19 21.51 | 16.29 | 16 | 37 59.28 | 28.22 |
| 55 | 2 46.46 | 0.77 | 25 | 3 39.94 | 1.28 | 55 | 5 16.65 | 2.53 | 25 | 9 1.30 | 6.88 | 15 | 19 37.80 | 16.67 | 18 | 38 27.50 | |

Factors for the correction of the mean Refraction.

Barometer in inches.

| | − | | + |
|---|---|---|---|
| 28.60 | ,0350 | 29.60 | ,0000 |
| 62 | ,0342 | 62 | ,0007 |
| 64 | ,0335 | 64 | ,0014 |
| 66 | ,0328 | 66 | ,0020 |
| 68 | ,0321 | 68 | ,0027 |
| 28.70 | ,0314 | 29.70 | ,0034 |
| 72 | ,0306 | 72 | ,0041 |
| 74 | ,0299 | 74 | ,0047 |
| 76 | ,0292 | 76 | ,0054 |
| 78 | ,0285 | 78 | ,0061 |
| 28.80 | ,0278 | 29.80 | ,0068 |
| 82 | ,0271 | 82 | ,0074 |
| 84 | ,0264 | 84 | ,0081 |
| 86 | ,0256 | 86 | ,0088 |
| 88 | ,0249 | 88 | ,0095 |
| 28.90 | ,0242 | 29.90 | ,0101 |
| 92 | ,0235 | 92 | ,0108 |
| 94 | ,0228 | 94 | ,0115 |
| 96 | ,0221 | 96 | ,0122 |
| 98 | ,0214 | 98 | ,0128 |
| 29.00 | ,0207 | 30.00 | ,0135 |
| 02 | ,0200 | 02 | ,0142 |
| 04 | ,0193 | 04 | ,0149 |
| 06 | ,0186 | 06 | ,0155 |
| 08 | ,0179 | 08 | ,0162 |
| 29.10 | ,0172 | 30.10 | ,0169 |
| 12 | ,0165 | 12 | ,0176 |
| 14 | ,0158 | 14 | ,0182 |
| 16 | ,0151 | 16 | ,0189 |
| 18 | ,0144 | 18 | ,0196 |
| 29.20 | ,0137 | 30.20 | ,0203 |
| 22 | ,0130 | 22 | ,0210 |
| 24 | ,0123 | 24 | ,0216 |
| 26 | ,0116 | 26 | ,0223 |
| 28 | ,0109 | 28 | ,0230 |
| 29.30 | ,0102 | 30.30 | ,0237 |
| 32 | ,0096 | 32 | ,0243 |
| 34 | ,0089 | 34 | ,0250 |
| 36 | ,0082 | 36 | ,0257 |
| 38 | ,0075 | 38 | ,0264 |
| 29.40 | ,0068 | 30.40 | ,0270 |
| 42 | ,0061 | 42 | ,0277 |
| 44 | ,0054 | 44 | ,0284 |
| 46 | ,0048 | 46 | ,0291 |
| 48 | ,0041 | 48 | ,0297 |
| 29.50 | ,0034 | 30.50 | ,0304 |
| 52 | ,0027 | 52 | ,0311 |
| 54 | ,0020 | 54 | ,0318 |
| 56 | ,0014 | 56 | ,0324 |
| 58 | ,0007 | 58 | ,0331 |

FAHRENHEIT's Thermometer.

| ° | Within. + | Without. + | ° | Within. − | Without. − |
|---|---|---|---|---|---|
| 21.5 | ,0632 | ,0470 | 49.0 | ,0000 | ,0080 |
| 22.0 | ,0621 | ,0460 | 49.5 | ,0011 | ,0090 |
| 22.5 | ,0609 | ,0450 | 50.0 | ,0022 | ,0100 |
| 23.0 | ,0598 | ,0440 | 50.5 | ,0033 | ,0110 |
| 23.5 | ,0586 | ,0430 | 51.0 | ,0044 | ,0120 |
| 24.0 | ,0575 | ,0420 | 51.5 | ,0055 | ,0130 |
| 24.5 | ,0563 | ,0410 | 52.0 | ,0066 | ,0140 |
| 25.0 | ,0552 | ,0400 | 52.5 | ,0077 | ,0150 |
| 25.5 | ,0540 | ,0390 | 53.0 | ,0088 | ,0160 |
| 26.0 | ,0529 | ,0380 | 53.5 | ,0099 | ,0170 |
| 26.5 | ,0517 | ,0370 | 54.0 | ,0110 | ,0180 |
| 27.0 | ,0506 | ,0360 | 54.5 | ,0121 | ,0190 |
| 27.5 | ,0494 | ,0350 | 55.0 | ,0132 | ,0200 |
| 28.0 | ,0483 | ,0340 | 55.5 | ,0143 | ,0210 |
| 28.5 | ,0471 | ,0330 | 56.0 | ,0154 | ,0220 |
| 29.0 | ,0460 | ,0320 | 56.5 | ,0165 | ,0230 |
| 29.5 | ,0448 | ,0310 | 57.0 | ,0176 | ,0240 |
| 30.0 | ,0437 | ,0300 | 57.5 | ,0187 | ,0250 |
| 30.5 | ,0425 | ,0290 | 58.0 | ,0198 | ,0260 |
| 31.0 | ,0414 | ,0280 | 58.5 | ,0209 | ,0270 |
| 31.5 | ,0402 | ,0270 | 59.0 | ,0220 | ,0280 |
| 32.0 | ,0391 | ,0260 | 59.5 | ,0231 | ,0290 |
| 32.5 | ,0379 | ,0250 | 60.0 | ,0242 | ,0300 |
| 33.0 | ,0368 | ,0240 | 60.5 | ,0253 | ,0310 |
| 33.5 | ,0356 | ,0230 | 61.0 | ,0264 | ,0320 |
| 34.0 | ,0345 | ,0220 | 61.5 | ,0275 | ,0330 |
| 34.5 | ,0333 | ,0210 | 62.0 | ,0286 | ,0340 |
| 35.0 | ,0322 | ,0200 | 62.5 | ,0297 | ,0350 |
| 35.5 | ,0310 | ,0190 | 63.0 | ,0308 | ,0360 |
| 36.0 | ,0299 | ,0180 | 63.5 | ,0319 | ,0370 |
| 36.5 | ,0287 | ,0170 | 64.0 | ,0330 | ,0380 |
| 37.0 | ,0276 | ,0160 | 64.5 | ,0341 | ,0390 |
| 37.5 | ,0264 | ,0150 | 65.0 | ,0352 | ,0400 |
| 38.0 | ,0253 | ,0140 | 65.5 | ,0363 | ,0410 |
| 38.5 | ,0241 | ,0130 | 66.0 | ,0374 | ,0420 |
| 39.0 | ,0230 | ,0120 | 66.5 | ,0385 | ,0430 |
| 39.5 | ,0218 | ,0110 | 67.0 | ,0396 | ,0440 |
| 40.0 | ,0207 | ,0100 | 67.5 | ,0407 | ,0450 |
| 40.5 | ,0195 | ,0090 | 68.0 | ,0418 | ,0460 |
| 41.0 | ,0184 | ,0080 | 68.5 | ,0429 | ,0470 |
| 41.5 | ,0172 | ,0070 | 69.0 | ,0440 | ,0480 |
| 42.0 | ,0161 | ,0060 | 69.5 | ,0451 | ,0490 |
| 42.5 | ,0149 | ,0050 | 70.0 | ,0462 | ,0500 |
| 43.0 | ,0138 | ,0040 | 70.5 | ,0473 | ,0510 |
| 43.5 | ,0126 | ,0030 | 71.0 | ,0484 | ,0520 |
| 44.0 | ,0115 | ,0020 | 71.5 | ,0495 | ,0530 |
| 44.5 | ,0103 | ,0010 | 72.0 | ,0506 | ,0540 |
| 45.0 | ,0092 | — | 72.5 | ,0517 | ,0550 |
| 45.5 | ,0080 | ,0010 | 73.0 | ,0528 | ,0560 |
| 46.0 | ,0069 | ,0020 | 73.5 | ,0539 | ,0570 |
| 46.5 | ,0057 | ,0030 | 74.0 | ,0550 | ,0580 |
| 47.0 | ,0046 | ,0040 | 74.5 | ,0561 | ,0590 |
| 47.5 | ,0034 | ,0050 | 75.0 | ,0572 | ,0600 |
| 48.0 | ,0023 | ,0060 | 75.5 | ,0583 | ,0610 |
| 48.5 | ,0011 | ,0070 | 76.0 | ,0594 | ,0620 |